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Features of Building Roads in Perma-Frozen Ground Regions

by

N. Puzakov

In conformity with the seven year plan for developing the national economy of the USSR in many important economical regions, the territory of which is partially situated in the zone of perma-frost grounds, it becomes necessary to develop auto-transportation. In this connection constructors of auto roads in these regions are faced with the task of solving numerous technical problems connected with the local natural characteristics.

In the Magadansk region, in Yakutia, in regions of Noril'sk and Vorkuta many automobile roads have already been built. The experience of their planning and operation allows to formulate proper technical instructions for further development of road construction under analogous conditions of the North.

As is known, the natural conditions of extreme North and North-East are distinguished first of all by the rough polar climate (duration of winter 8 - 10 months, air temperature to -65° , snowstorms and winds with a speed of up to 40 m/sec, short rainy Summer). These climatic characteristics make road building very difficult.

Furthermore, for the construction of roads the local geological and hydrological conditions are highly unfavorable. The ice-saturated soils situated not too deep from the surface lose their strength during thawing, forming greater and irregular sags. The presence of impermeable perma-frozen grounds near the surface creates conditions for the formation of ground pressure superfreezing waters. During winter time freezing of the ground these waters come up to the surface in form of ice layers, flooding roads and artificial installations. In the southern part of these regions is observed a sharp bulging of the earth and especially pile supports and foundations of small

artificial installations. In flatland, tundra or bottom lands, and also along marsh lands and watersheds and inclined slopes of forest zone it is often impossible to lay reserves for use of local grounds.

In addition in the mountainous regions of the North and North-East are scattered gravel-wood or gravel-sand and sandy loam grounds, suitable for road works.

Finally, to the unfavorable qualities of road building in the discussed regions we must also add the higher cost of road building, connected with specific local conditions (distance from central regions and the limitedness and periodicity of transport links, poor industrial base for road construction, absence of a fixed open pit installation etc.).

Taking under consideration all the enumerated features it is possible to make the following basic recommendations on the planning and construction of automobile roads under conditions of perma-frozen grounds.

When laying out an automobile road it is necessary to plan same if possible over rocky and skeletal grounds, the thawing of which causes no deformation of the earthen roadway.

In intersected and mountainous regions roads should be built over valleys and over windward sloping inclines, avoiding the bottoms of the slopes, where in the winter time snowdrifts do accumulate. Under other conditions being equal roads should be built over slopes of southern exposure, where there is lesser icing and peatiness of the grounds.

When building auto-roads over flatlands it is necessary to avoid sections with unfavorable frozen state hydrogeological conditions (with close by deposition of interred ice, with unstable ice-saturated grounds), as well as sections exposed to snow drifts and ice formation. When it is necessary to lay a road near effective ravines, steep (steeper than 1:5) inclines with ice saturated grounds, when intersecting sections with formations of ices and bulges, drainageless spaces, hollows in coherent and ice-saturated dust like grounds individual planning of measures should be provided,

in order to assure stability of the earthen roadway of the road against damages. Sections of individual planning should be designated in the period of preliminary explorations and thoroughly investigated during engineering- geological explorations.

Preliminary designation of sections with underground ice depositions may be realized on the basis of aerial photography in scale of 1:20000, which well fixes the polygonal forms of the surface of the tundra, typical for sections with close deposits of underground ice veins.

When making a detailed exploration of sections, requiring individual planning, frozen-ground photo is made in scale of 1:5000. Electric exploration can be used for outlining sections with underground ice.

The earthy roadbed of automobile roads under conditions of spreading perma-frozen grounds should be built preferably over embankments. The height of the embankment is determined in relation to the properties and condition of the grounds, with consideration of the effect of constructing the embankment on the position of the upper boundary of permafrozen grounds under given hydrological and climatic conditions, and with consideration of the snowdrifts as well.

In crushed stone grounds, having no ice layers through the entire depth of their thawing, as well as in less icy fine grained grounds with humidity of less than 0.6 from point of fluidity (regardless of their temperature) the earthy roadway can be planned in accordance with general standards and technical conditions.

In fine-grained grounds, with a humidity of less than 0.8 - 0.9 of the fluidity point, and especially in sandy and sandy loam grounds, in localities with assured water drainage at unstable nature of freezing, with temperature in the zone of zero amplitudes of no less than -2° the earthy roadbed is planned with consideration of preliminary thawing and drying of grounds of the active layer.

In fine-grained ice-saturated soils with humidity of more than 0.8 of fluidity point at stable nature of freezing, with temperature in the zone of zero amplitudes of not more than -3° the earthy roadbed should be planned in embankments by the

method of partial preservation of soils of the active layer in frozen state without disturbing the natural contour of the locality. The height of the embankment should be determined by thermotechnical calculation with testing for strength. To preserve the natural conditions the vegetation layer is not removed, roots are not uprooted, but cut in level with the ground. Timber and shrubs are cut only along the strip, designated directly for the earthy roadbed and other installations.

The most widely employed method of constructing roads (auto roads) in regions of permafrost grounds is the one, when all structural measures are carried out with consideration of preserving the frozen state. Applicable to this method we are discussing below a number of most effective measures, recommended for road builders.

Embankment of draining grounds should be built only in winter time, after partial freezing of active layer soils, assuring the passing of automobiles. The embankment is built to full height with layer packings. With the advent of positive temperatures the job of building the embankment should be discontinued.

When it is necessary to reduce (because of conditions of applying the projected line) the height of the embankment in comparison with the calculated one it is advisable to add to its construction heat insulating layers from local structural materials (bellows, peat, dust, slag) or replace the unstable dusty bulgy grounds with drainage stable grounds. The thickness of the replaced layer together with the embankment is determined by calculation. It should be no less than 0.8 m. Over horizontal sections and slanting slopes with lateral sloping of up to 1:5 (20%) the height of the embankment from the hill side should also be no less than 0.8 m (without grooves).

In fine-grained, ice saturated soils with a capacity of the active layer h_a of more than 1.5 m, and also during the presence in the base of the embankment at a depth of less than $2h_a$ of ice veins or buried ice the height of the embankment should be accepted by the technological calculation, but no less than 1.3 m with an arrangement under the embankment of an insulation layer made up of local little heat conductive materials (bellows, dry peat with a thickness of 30 cm or pole floor).

Along sections with interred ice embankments are planned with berms of 3 meters in width on each side, 0.6 to 1 m in height to prevent contact of slopes with daily surface against the effects of melting.

On slopes steeper than 1:5 the height of the embankment made of draining soils should be no less than 0.6 m. In this case are necessary ledges with peat-moss insulation; no gutters are necessary.

In peaty-hillock full tundras, peat bogs and watersheds embankments should be made of drainage soils with a height of no less than 1 m over log floorings.

In swamped sections is recommended preliminary drainage of land reserves by surface water drainage. When building embankments of undrained dust like argillaceous soil and sandy loams their permitted humidity (moisture) should be not more than 1.2 of the optimum; The upper part of the embankment should be built of skeletal sand loam not dusty soils with a thickness, determinable by calculation, but no less than 0.4 m. Degree of packing the soil should be no less than 0.9 .

Gaps should be built only in nonsagging stable grounds. Over sections with subterranean ice gaps are permitted only under conditions of ice deposits above the planned markings of the borders of the earthy roadbed. Ice in the slopes should be removed and replaced with drainage soil for a calculated depth. If the construction of gaps in ice-saturated soil cannot be avoided, we speak here about soils which during thawing turn into liquid state, such earth must be replaced by drainage soil stable to a depth, determinable by calculation, but no less than 0.8 m from the edge, with drainage of water from -----trough into channels or trays. Cut outs (gaps) with a depth of ----- up to 2 m should be built only in open form. Gaps, cutting through water bearing horizons, should be fenced off by drainage installation or counter icing installations.

Slopes of embankments and gaps are planned by general NiTU, with the exception of wet gaps where the slopes should have a foundation of 1:3. The lower part of slopes should be reinforced or covered with thermoinsulation with such a consideration, that

there should be no increase in active layer under the slopes. Reinforcing of slopes is necessary immediately after completing the earth piling tasks and after completing the thermoinsulation layer - in the process of their execution. Obligatory reinforcement goes for slopes of gaps and embankments, made of clayey grounds, fine and powder like sands.

Water drainage in skeletal soils is realized by ordinary channels. On sloping sections are built raised gutters. The lower edge of the gutter on sections without the presence of icicles is situated not closer than 5 m from the edge of the slanting gap, and on highly ice saturated soils - not closer than 20 m. In swampy areas, where under the vegetation layer are situated highly ice saturated soils or ice veins and interred ice, the building of mountainous water drains is not necessary. In this case water drainage is provided by the building of a mountain frozen state shaft, placed not closer than 15 m from the bottom of the embankment. The slopes of the shaft at bottom of embankment slope are reinforced with wooden shields on moss. Height of the frozen shaft should be no less than 0.7 m. For greater stability the frozen shaft is thermoinsulated, and on slopes with a steepness of 1:5 in its interior is built a fencing.

Water passing man-made installations along the length of automobile roads are situated at various sections and in lower places by no less than 200-300 m, and along sloping sections every 100-200 m.

Removal of water from the road should be assured before the earthy roadbed is being prepared. In the construction of water draining structures operations in stages are not permitted.

Trough in ice saturated soils, where a greater number of sags can be anticipated, they should not be situated closer than 20 m from the field edge and their depth should be minimal. The necessary profile of the troughs in these case is provided on account of their broadening. Minimum longitudinal tiltings of troughs is accepted at 0.003 - 0.005.

When planning and building automobile roads by the preliminary thawing method ("opening") of frozen ground it is necessary to take a number of additional steps, intended to speed up the thawing and draining of frozen ground. To such measures belong first of all the construction of cut throughs beyond the limits of embankment ——— slopes and gaps or slopes of troughs at a distance, equalling the height of trees. In addition, by the full width of the earthy roadbed with reserves is removed the moss-vegetation layer and roots of trees are uprooted. To trap and drain water, forming during the thawing of frozen grounds and during the opening of water bearing horizons, in high land slopes will be built deeper raised troughs, drainages, passages, additional drainage channels, filtering dams.

If preliminary drainage of soil in the base of embankments cannot be done rapidly then the lower part of the latter should be built of drainage soils. In rough points is permitted the laying of a timber floor 12-16 cm in diameter.

The height of the embankment built of drainage soil is determined by strength calculation. If the ground has soft-plastic consistency, then the height of the embankment should be no less than 0.4 m.

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